Special Flood Hazard Evaluation Report

Chagrin River and Aurora Branch

Village of Bentleyville, Cuyahoga County, Ohio

Prepared for the
Ohio State Department of Natural Resources

US Army Corps
of Engineers
Buffalo District

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This report documents the results of an investigation to determine the potential flood Situation along the Chagrin River and Aurora Branch within the Village of Bentleyville, Cuyahoga County, Ohio. The study reach includes the Chagrin River from the northern corporate boundary, upstream, to the eastern corporate boundary. The Aurora Branch was studied from its confluence with the Chagrin River to the southern corporate boundary. Consideration of a rock ledge located approximately 9600 feet downstream of the confluence of the Chagrin River with the Aurora Branch in this study produced significant increases in flood elevations for the Chagrin River. In addition, the current study modeled the Aurora Branch for its entire length within the Village of Bentleyville therefore producing more accurate results. Findings from this study may warrant reexamining the adjoining upstream study area because flood elevations between the two studies are not in concurrence.

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SPECIAL FLOOD HAZARD EVALUATION REPORT
CHAGRIN RIVER AND AURORA BRANCH
VILLAGE OF BENTLEYVILLE, CUYAHOGA COUNTY, OHIO

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INTRODUCTION

This Special Flood Hazard Evaluation Report documents the results of an investigation to determine the potential flood situation along the Chagrin River and Aurora Branch within the Village of Bentleyville, Cuyahoga County, Ohio. This study was conducted at the request of the Ohio Department of Natural Resources under the authority of Section 206 of the 1960 Flood Control Act, as amended. The study reach includes the Chagrin River from the northern corporate boundary, upstream, to the eastern corporate boundary. The Aurora Branch was studied from its confluence with the Chagrin River to the southern corporate boundary.

The Village of Bentleyville is located in northeastern Cuyahoga County, approximately 21 miles southeast of Cleveland and 58 miles northwest of Youngstown. The Bentleyville population is 674 according to the 1990 Census (Reference 1). The Chagrin River originates in the Town of Chardon and flows in a southwest direction before turning north and flowing through the Village of Bentleyville to Lake Erie.

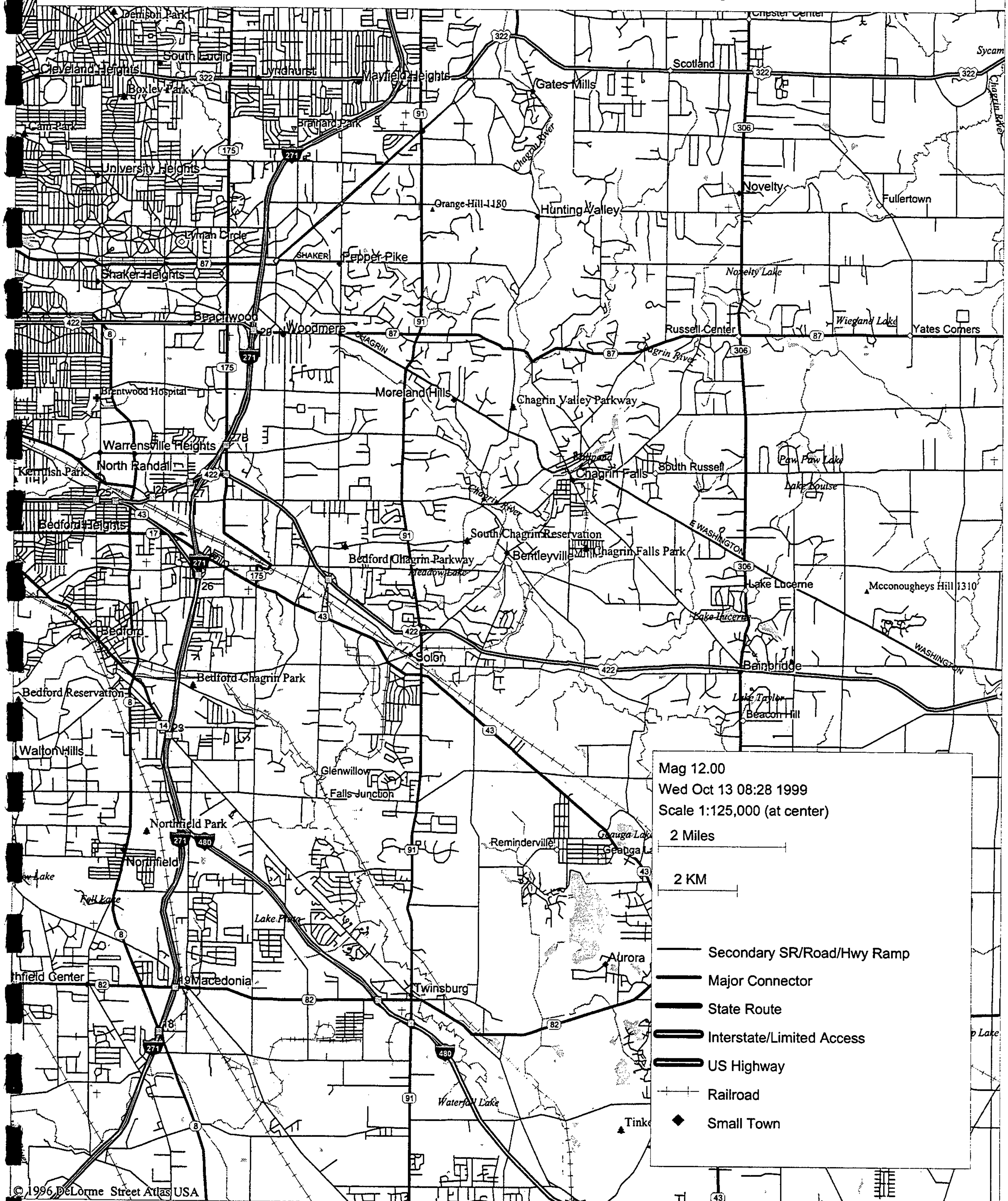
Knowledge of potential floods and flood hazards is important in land use planning. This report identifies the 100-year and 500-year flood plains for the reaches studied.

Information developed for this study will be used by local officials to manage future flood plain development. While the report does not provide solutions to flood problems, it does furnish a suitable basis for the adoption of land use controls to guide flood plain development, thereby preventing intensification of the flood loss problem. It will also aid in the development of other flood damage reduction techniques to modify flooding and reduce flood damages which might be embodied in an overall Flood Plain Management (FPM) program. Other types of studies, such as environmental and current and future land use analysis of the flood plain, would also profit from this information.

Although Flood Insurance Rate Maps have been developed for the community, recent flooding events indicate that changes may have occurred which effect the flood plain. Currently, the area is now experiencing residential development pressure, and local officials requested detailed flood plain information to assist them in managing development.

Additional copies of this report can be obtained from the Ohio State Department of Natural Resources until its supply is exhausted, and the National Technical Information Service of the U.S. Department of Commerce, Springfield, Virginia 22161, at the cost of reproducing the report. The Buffalo District Corps of Engineers will provide technical assistance and guidance to planning agencies in the interpretation and use of the hydrologic data obtained for this study.

Figure 1 - Vicinity Map - Bentleyville, Ohio



PRINCIPAL FLOOD PROBLEMS

Although flooding may occur during any season, the principal flood problems have occurred during winter and spring months and are usually the result of spring rains and or snowmelt.

Flood Magnitudes and Their Frequencies

Special flood hazard areas are determined with reference to the "100-year" flood standard, which is a national standard on which flood regulations are based. The "100-year" flood, also referred to as a "base flood," is defined as the flood having a 1 percent probability of being equaled or exceeded in any given year. The risk of experiencing a flood of this magnitude increases with the length of time considered. While it represents the long-term average recurrence interval for a flood of this magnitude, such floods may be experienced in any given year. There is a greater than 50 percent probability that a "100-year" event will occur during a 70-year life time, and there is a 26 percent (about one in four) probability of experiencing such a flood over a typical 30-year mortgage period. The "100-year" flood is more properly termed the 1 percent chance exceedance flood or 1 percent flood, which represents its true probability of being equaled or exceeded in any year.

Hazards and Damages of Large Floods

The extent of damage caused by any flood depends on the topography of the flooded area, the depth and duration of flooding, the velocity of flow, the rate of rise in water surface elevation, and development of the flood plain. Deep water flowing at a high velocity and carrying floating debris would create conditions hazardous to persons and vehicles which attempt to cross the flood plain. Generally, water 3 or more feet deep, which flows at a velocity of 3 or more feet per second, could easily sweep an adult off his feet and create definite danger of injury or drowning. Rapidly rising and swiftly flowing floodwater may trap persons in homes that are ultimately destroyed or in vehicles that are ultimately submerged or floated. Since water lines can be ruptured by deposits of debris and by the force of flood waters, there is the possibility of contaminated domestic water supplies. Damaged sanitary sewer lines and sewage treatment plants could result in the pollution of floodwaters and could create health hazards. Isolation of areas by floodwater could create hazards in terms of medical, fire, or law enforcement emergencies.

HYDROLOGIC ANALYSES

Hydrologic analyses were carried out to determine the peak discharge-frequency relationships for the flooding sources affecting the community. Hydrology was developed for two reaches on the Chagrin River and two reaches on Aurora Branch. For both streams, the peak discharges were calculated using Techniques for Estimating Flood-Peak Discharges of Rural, Unregulated Streams in Ohio developed by the United States Geological Survey (Reference 2). Discharges for the 1 percent (100-year) and 0.2 percent (500-year) floods were analyzed for this study. The 0.2 percent flood peak discharge was extrapolated from the discharge-frequency relationship developed using annual peak discharges of the 50 percent (2-year), 20 percent (5-year), 10 percent (10-year), 4 percent (25-year), 2 percent (50-year), and 1 percent floods. Table 1 summarizes the peak discharges for reaches of the Chagrin River and Aurora Branch.

TABLE 1
SUMMARY OF DISCHARGE

Flooding Source and Location	Drainage Area (sq mi)	Peak Discharges 10 percent (cfs)	4 percent (cfs)	2 percent (cfs)	1 percent (cfs)	0.2 percent (cfs)
Chagrin River						
Down stream Bentleyville corporate limit	124	8920	11555	13570	15670	21600
At confluence with Aurora Branch	61	4890	6325	7425	8565	11700
Aurora Branch						
At confluence with Chagrin River	58	4670	6035	7080	8160	10130
Approximately 1450 feet Upstream of Solon Rd.	54	4400	5690	6680	7700	10070

HYDRAULIC ANALYSES

Analyses of the hydraulic characteristics of flooding from sources studied were carried out to provide estimates of the elevations for the 10 percent, 2 percent, 1percent and 0.2 percent exceedance floods.

Cross-section data for the backwater analyses of the Chagrin River and Aurora Branch were obtained from field inspections performed by Buffalo District personnel. Additional data were obtained from detailed topographic maps provided by the Cuyahoga County Engineer (Reference 3) and from the previous Village of Bentleyville Flood Insurance Study (Reference 4). Plan diagrams, provided by the Village of Bentleyville, and the existing Flood Insurance Study were used to determine elevation and structural geometry of bridges, culverts, and the rock ledge approximately 9600 feet downstream of the confluence with the Aurora Branch.

Water surface elevations of the 1 percent and 0.2 percent flood events were computed using the COE HEC-RAS step-backwater computer program (Reference 5). Starting water surface elevations for the Chagrin River and Aurora Branch were taken from the Village of Bentleyville Flood Insurance Study dated August 1980.

Locations of the selected cross-sections used in the hydraulic analyses are shown on the Flood Profile (Plate 1) and on the Flooded Areas Map which accompany this report.

Channel and overbank roughness factors (Manning's "n") used in the hydraulic computations were selected using engineering judgement and were based on field observations of the stream and flood plain areas. The values for Manning's "n" and the contraction and expansion coefficients are shown in Table 2.

TABLE 2
MANNING'S "N" AND CONTRACTION & EXPANSION COEFFICIENTS

Flooding Source	Channel	Overbank	Contraction	Expansion
Chagrin River	0.03-0.035	0.08	0.1	0.3
Aurora Branch	0.03-0.045	0.05-0.055	0.1-0.3	0.3-0.5

Flood profiles were drawn showing the computed water surface elevations for the selected recurrence intervals. The flood plain boundaries were delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using the topographic maps and spot elevations obtained during field inspection. Small areas within the flood plain boundaries may be above the flood elevations, but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

Floodways were determined for the streams studied in detail. Floodway encroachments were based on equal conveyance reduction from each side of the flood plain, with adjustments as necessary to provide functional and manageable floodways. At the request of the ODNR, the maximum increase in stage due to encroachment was limited to 1 foot, provided that hazardous velocities were not produced. Floodway widths were computed at cross sections for the Chagrin River and for Aurora Branch. Between cross sections, the floodway boundaries were interpolated. The results of the floodway calculations are summarized for selected cross sections in Table 3.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profile are considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

The current study did not identify new elevation reference marks or modify elevation reference marks from the previous study.

The previously mentioned flood events may have resulted from isolated storms or other intangibles. A comparison of this study with the 1980 FIS indicates a significant increase in flood elevations for the study area. The 1 percent flood elevations of this study do not concur within 1 foot of those reported for the upstream community (Village of Chagrin Falls). The 1 percent flood elevation reported for the upstream corporate limit of the Village of Bentleyville in this study is approximately 2 feet higher than that reported for the downstream limit of the Village of Chagrin Falls 1980 FIS.

UNIFIED FLOOD PLAIN MANAGEMENT

Historically, the alleviation of flood damage has been accomplished almost exclusively by the construction of protective works such as reservoirs, channel improvements, and floodwalls and levees. However, in spite of the billions of dollars that have already been spent for construction of well-designed and efficient flood control works, annual flood damages continue to increase because the number of persons and structures occupying floodprone lands is increasing faster than protective works can be provided.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
CHAGRIN RIVER								
A	619[1]	149	1592	9.8	825.2	825.2	825.8	0.6
B	658[1]	152	1577	9.9	825.2	825.2	825.9	0.7
C	1383[1]	213	1386	11.3	826.9	826.9	827.9	1.0
D	1697[1]	260	1847	8.5	829.3	829.3	829.3	0.0
E	2200[1]	559	3748	4.2	830.9	830.9	830.9	0.0
F	3781[1]	163	1765	4.9	834.7	834.7	835.4	0.7
G	5155[1]	460	4577	1.9	835.9	835.9	836.8	0.9
H	5981[1]	166	1240	6.9	835.7	835.7	836.5	0.8
I	6837[1]	256	1762	4.9	838.2	838.2	839.2	1.0
AURORA BRANCH								
A	1916[2]	77	547	14.9	836.4	836.4	836.4	0.0
B	2888[2]	90	719	11.4	841.7	841.7	842.7	1.0
C	3891[2]	91	571	14.3	853.9	853.9	853.9	0.0
D	4846[2]	96	584	14.0	864.3	864.3	864.4	0.1
E	6340[2]	90	1030	7.9	889.0	889.0	889.2	0.2
F	7035[2]	130	1514	5.4	889.6	889.6	890.3	0.7
G	8943[2]	370	2937	2.6	890.4	890.4	891.2	0.8
H	10477[2]	480	2890	2.7	891.3	891.3	892.0	0.7
I	12815[2]	240	1313	5.9	892.5	892.5	893.5	1.0
J	13200[2]	400	2246	3.4	893.6	893.6	894.5	0.9

[1]FEET ABOVE CORPORATE LIMIT
[2]FEET ABOVE MOUTH

Recognition of this trend has forced a reassessment of the flood control concept and resulted in the broadened concept of unified flood plain management programs. Legislative and administrative policies frequently cite two approaches: structural and nonstructural, for adjusting to the flood hazard. In this context, "structural" is usually intended to mean adjustments that modify the behavior of floodwaters through the use of measures such as dams and channel work. "Nonstructural" is usually intended to include all other adjustments in the way society acts when occupying or modifying a flood plain (e.g., regulations, floodproofing, insurance, etc.). Both structural and nonstructural tools are used for achieving desired future flood plain conditions. There are three basic strategies which may be applied individually or in combination: (1) modifying the susceptibility to flood damage and disruption, (2) modifying the floods themselves, and (3) modifying (reducing) the adverse impacts of floods on the individual and the community.

Modify Susceptibility to Flood Damage and Disruption

The strategy to modify susceptibility to flood damage and disruption consists of actions to avoid dangerous, economically undesirable, or unwise use of the flood plain. Responsibility for implementing such actions rests largely with the non-Federal sector and primarily at the local level of government.

These actions include restrictions in the mode and the time of occupancy; in the ways and means of access; in the pattern, density, and elevation of structures and in the character of their materials (structural strength, adsorptiveness, solubility, corrodibility); in the shape and type of buildings and in their contents; and in the appurtenant facilities and landscaping of the grounds. The strategy may also necessitate changes in the interdependencies between flood plains and surrounding areas not subject to flooding, especially interdependencies regarding utilities and commerce. Implementing mechanisms for these actions include land use regulations, development and redevelopment policies, floodproofing, disaster preparedness and response plans, and flood forecasting and warning systems.

Different tools may be more suitable for developed or underdeveloped flood plain or for urban or rural areas. The information contained in this report is particularly useful for the preparation of flood plain regulations.

a. Flood Plain Regulations.

Flood plain regulations apply to the full range of ordinances and other means designed to control land use and construction within floodprone areas. The term encompasses zoning ordinances, subdivision regulations, building and housing codes, encroachment line statutes, open area regulations, and other similar methods of management which affect the use and development of floodprone areas.

Flood plain land use management does not prohibit use of floodprone areas; to the contrary, flood plain land use management seeks the best use of flood plain lands. The flooded area maps and the water surface profiles contained in this report can be used to guide development in the flood plain. The elevations shown on the profile should be used to determine flood heights because they are more accurate than the outlines of flooded areas. It is recommended that development in areas susceptible to frequent flooding adhere to the principles expressed in Executive Order 11988 - Flood Plain Management, whose objective is to "... avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of flood plains ... whenever there is a practicable alternative." Accordingly, development in areas susceptible to frequent flooding should consist of construction which has a low damage potential such as parking areas, parks, and golf courses. High value construction such as buildings, should be located outside the flood plain to the fullest extent possible. In instances where no practicable alternative exists, the land should be elevated to minimize damages. If it is uneconomical to elevate the land in these areas, means of floodproofing the structure should be given careful consideration.

b. Development Zones.

A flood plain consists of two zones. The first zone is the designated "floodway" or that cross sectional area required for carrying or discharging the anticipated flood waters with a maximum 1-foot increase in flood level (New York State Department of Environmental Conservation standard). Velocities are the greatest and most damaging in the floodway. Regulations essentially maintain the flow-conveying capability of the floodway to minimize inundation of additional adjacent areas. Uses which are acceptable for floodways include parks, parking areas, open spaces, etc. The second zone of the flood plain is termed the "floodway fringe" or restrictive zone, in which inundation might occur but where depths and velocities are generally low. Although not recommended if practicable alternatives exist, such areas can be developed provided structures are placed high enough or floodproofed to be reasonably free from flood damage during the 1 percent flood. Typical relationships between the floodway and floodway fringe are shown in Figure 2.

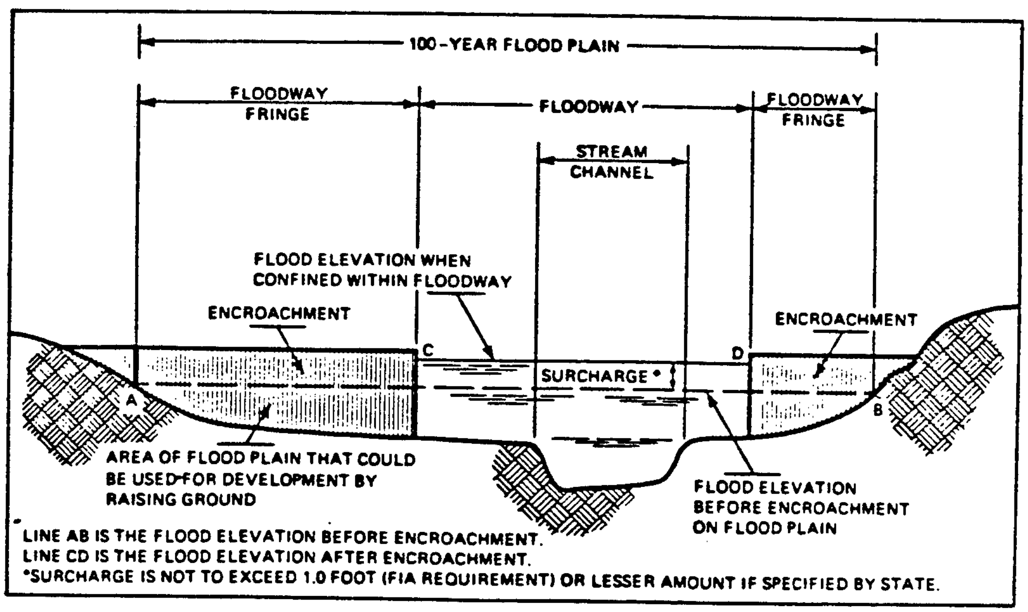


Figure 2 - Floodway Schematic

c. Formulation of Flood Plain Regulations.

Formulation of flood plain regulations in a simplified sense involves selecting the type and degree of control to be exercised for each specific flood plain. In principle, the form of the regulations is not as important as a maintained adequacy of control. The degree of control normally varies with the flood hazard as measured by depth of inundation, velocity of flow, frequency of flooding, and the need for available land. Considerable planning and research is required for the proper formulation of flood plain regulations. Formulation of flood plain regulations may require a lengthy period of time during which development is likely to occur. In such cases, temporary regulations should be adopted and amended later as necessary.

Modify Flooding

The traditional strategy of modifying floods through the construction of dams, dikes, levees and floodwalls, channel alterations, high flow diversions and spillways, and land treatment measures has repeatedly demonstrated its effectiveness for protecting property and saving lives, and it will continue to be a strategy of flood plain management. However, in the future, reliance solely upon a flood modification strategy is neither possible nor desirable. Although the large capital investment required by flood modifying tools has been provided largely by the Federal government, sufficient funds from Federal sources have not been and are not likely to be available to meet all situations for which flood modifying measures would be both effective and economically feasible. Another consideration is that the cost of maintaining and operating flood control structures falls upon local governments.

Flood modifications acting alone leave a residual flood loss potential and can encourage an unwarranted sense of security leading to inappropriate use of lands in the areas that are directly protected or in adjacent areas. For this reason, measures to modify possible floods should usually be accompanied by measures to modify the susceptibility to flood damage, particularly by land use regulations.

Modify the Impact of Flooding on Individuals and the Community

A third strategy for mitigating flood losses consists of actions designed to assist individuals and communities in their preparatory, survival, and recovery responses to floods. Tools include information dissemination and education, arrangements for spreading the costs of the loss over time, purposeful transfer of some of the individual's loss to the community by reducing taxes in flood prone areas, and the purchase of Federally subsidized flood insurance.

The distinction between a reasonable and unreasonable transfer of costs from the individual to the community can also be regulated and is a key to effective flood plain management.

CONCLUSION

Changes in hydrology and hydraulics reflected in this study are the result of a more detailed analysis. New modeling procedures and additional data have been used in the analysis of the Chagrin River and the Aurora Branch. Consideration of a rock ledge located approximately 9600 feet downstream of the confluence of the Chagrin River with the Aurora Branch in this study produced significant increases in flood elevations for the Chagrin River. In addition, the current study modeled the Aurora Branch for its entire length within the Village of Bentleyville therefore producing more accurate results. Findings from this study may warrant reexamining the adjoining upstream study area because flood elevations between the two studies are not in concurrence.

This report presents local flood hazard information for the Chagrin River in the Village of Bentleyville, Ohio. The U.S. Army Corps of Engineers, Buffalo District, will provide interpretation in the application of the data contained in this report, particularly as to its use in developing effective flood plain regulations. Requests should be coordinated with the Ohio State Department of Natural Resources.

GLOSSARY

BACKWATER EFFECT	The resulting rise in water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.
BASE FLOOD	A flood which has an average return interval in the order of once in 100 years, although the flood may occur in any year. It is based on statistical analysis of streamflow records available for the watershed and analysis of rainfall and runoff characteristics in the general region of the watershed. It is commonly referred to as the "100-year flood."
DISCHARGE	The quantity of flow in a stream at any given time, usually measured in cubic feet per second (cfs).
FLOOD	An overflow of lands not normally covered by water. Floods have two essential characteristics: the inundation of land is temporary and the lands are adjacent to and inundated by overflow from a river, stream, ocean, lake, or other body of standing water. Normally a "flood" is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, and rise of groundwater coincident with increased streamflow.
FLOOD CREST	The maximum stage or elevation reached by floodwaters at a given location.
FLOOD FREQUENCY	A statistical expression of the percent chance of exceeding a discharge of a given magnitude in any given year. For example, a <u>100-year flood</u> has a magnitude expected to be exceeded on the average of once every hundred years. Such a <u>flood</u> has a 1 percent chance of being exceeded in any given year. Often used interchangeably with <u>RECURRENCE INTERVAL</u>.
FLOOD PLAIN	The areas adjoining a river, stream, watercourse, ocean, lake, or other body of standing water that have been or may be covered by floodwater.
FLOOD PROFILE	A graph showing the relationship of water surface elevation to location; the latter generally expressed as distance upstream from a known point along the approximate centerline of a stream of water that flows in an open channel. It is generally drawn to show surface elevation for the rest of a specific flood, but may be prepared for conditions at a given time or stage.
FLOOD STAGE	The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.
FLOODWAY	The channel of a watercourse and those portions of the adjoining flood plain required to provide for the passage of the selected flood (normally the 100-year flood) with an insignificant increase in the flood levels above that of natural conditions. As used in the National Flood Insurance Program, floodways must

be large enough to pass the 100-year flood without causing an increase in elevation of more than a specified amount (1 foot in most areas).

RECURRENCE INTERVAL — A statistical expression of the average time between floods exceeding a given magnitude (see FLOOD FREQUENCY).

REFERENCES

1. U.S. Department of Commerce, Bureau of the Census, 1990 Census of the Population and Housing, Washington, D.C.

2. U.S. Department of the Interior, Geological Survey, Techniques for Estimating Flood-Peak Discharges of Rural, Unregulated Streams In Ohio, Water Resources Investigation Report 89-4126, 1990.

3. Cuyahoga County Engineer, Topographic Maps, October 1997

4. Federal Emergency Management Agency, Flood Insurance Study, Village of Bentleyville, Ohio, August 1, 1980.

5. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS, River Analysis System, Version 2.2, Davis, California, 1988.

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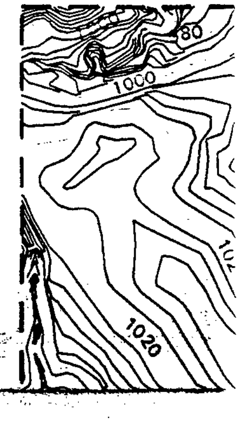

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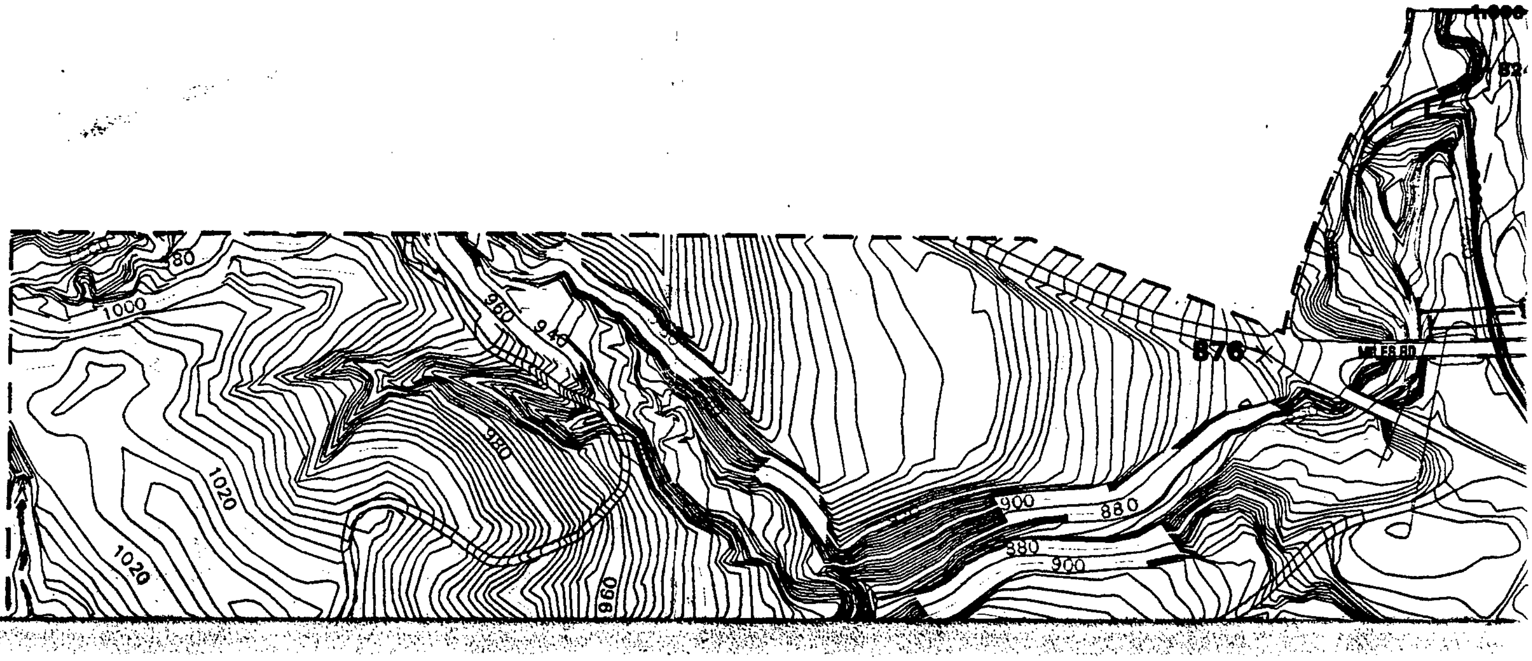

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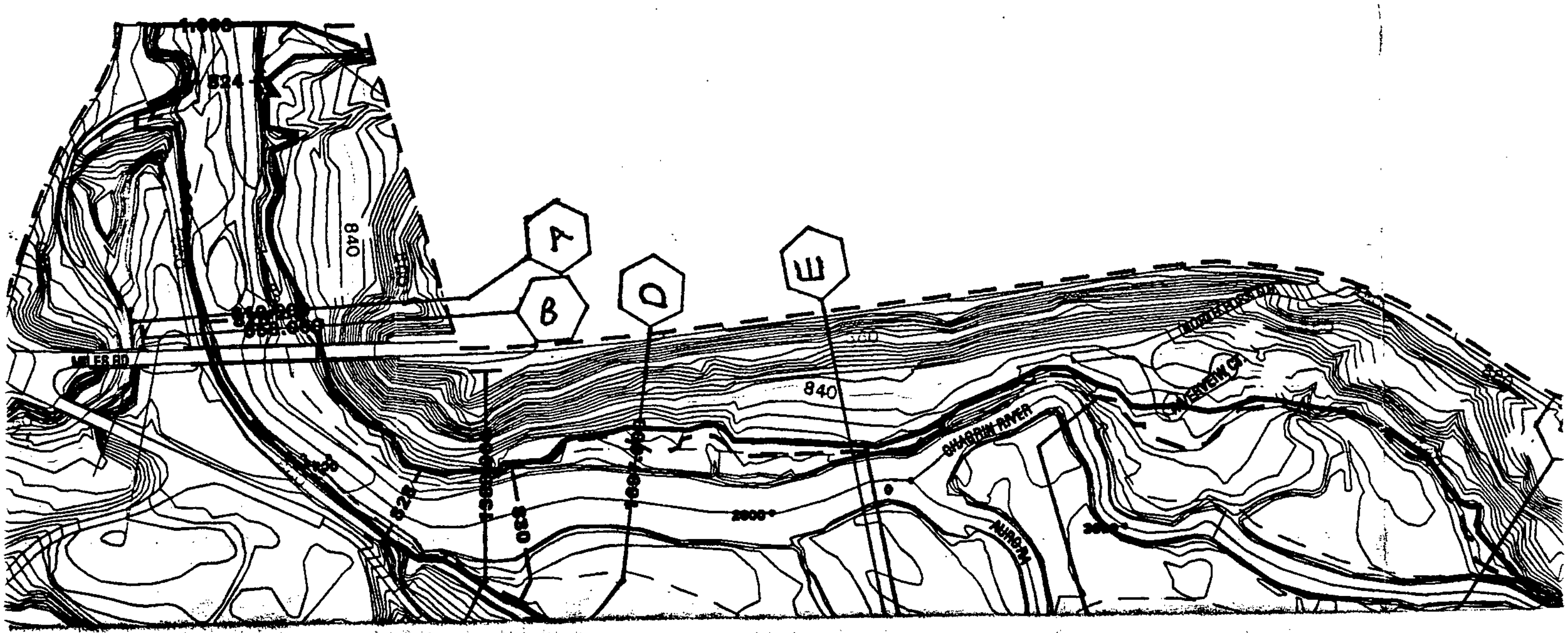

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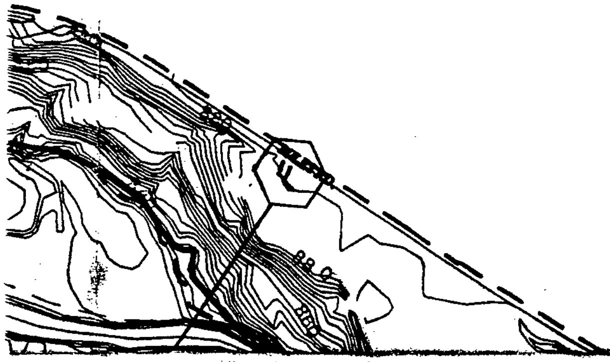

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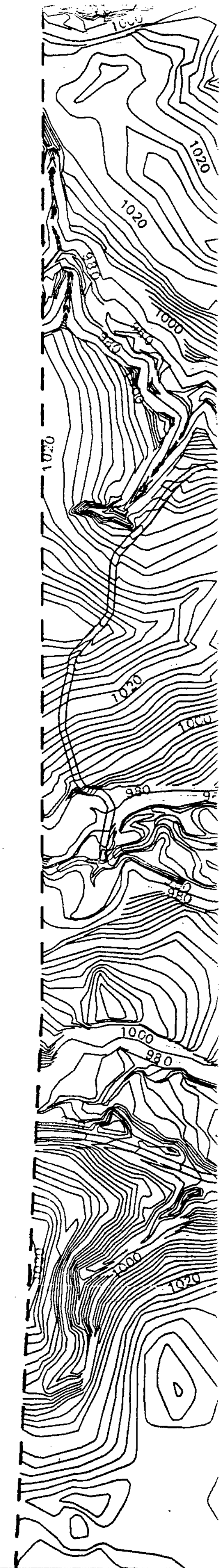
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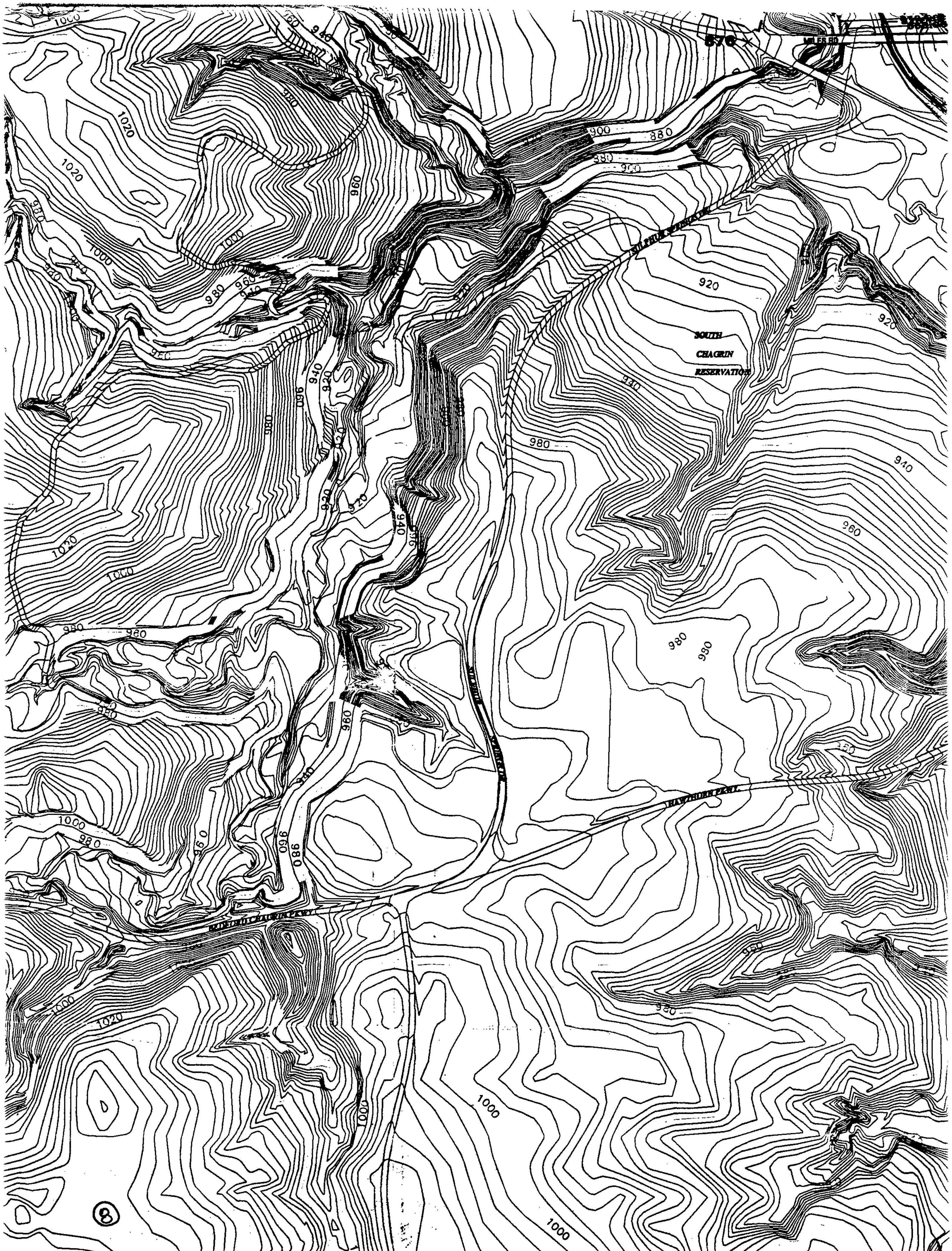
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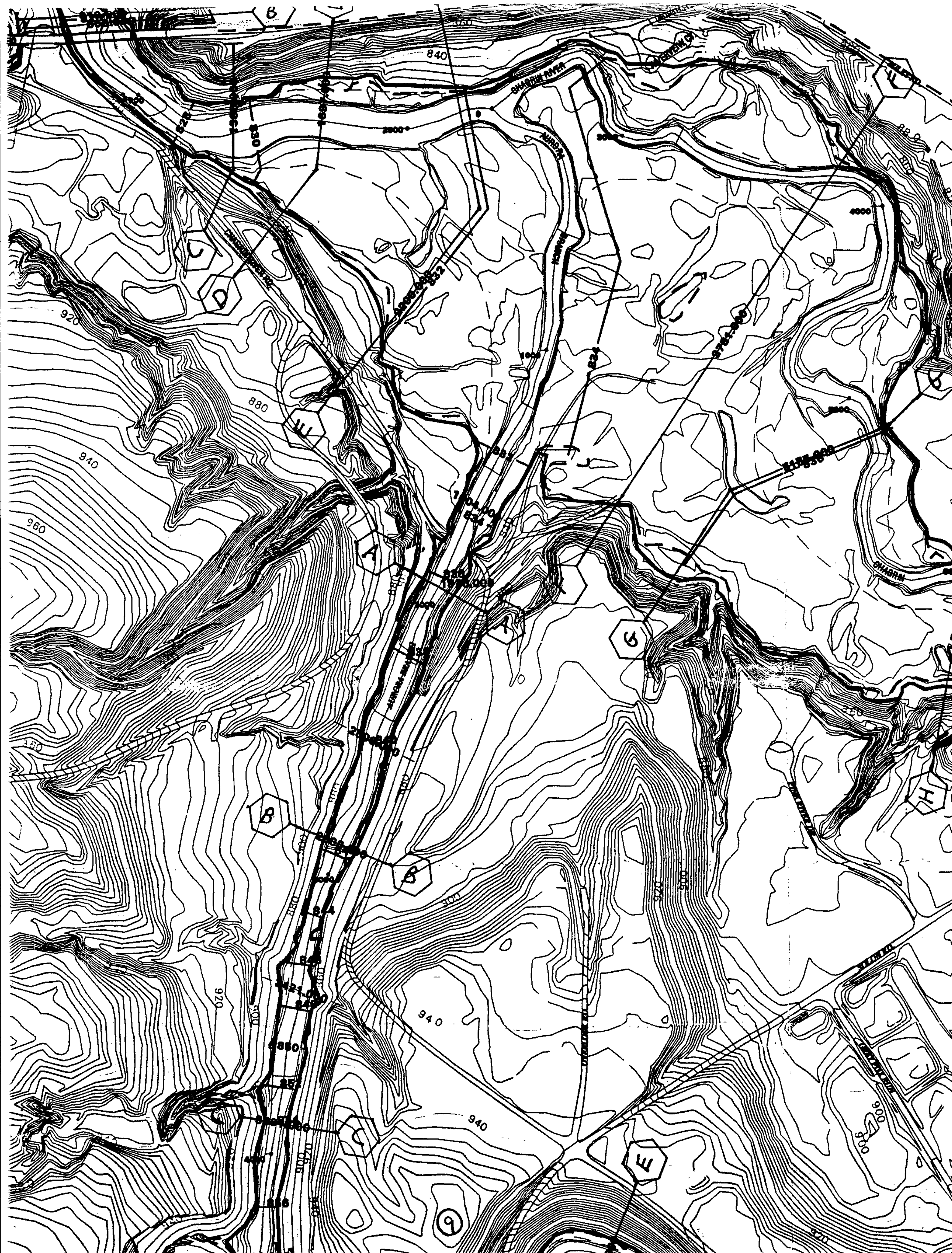
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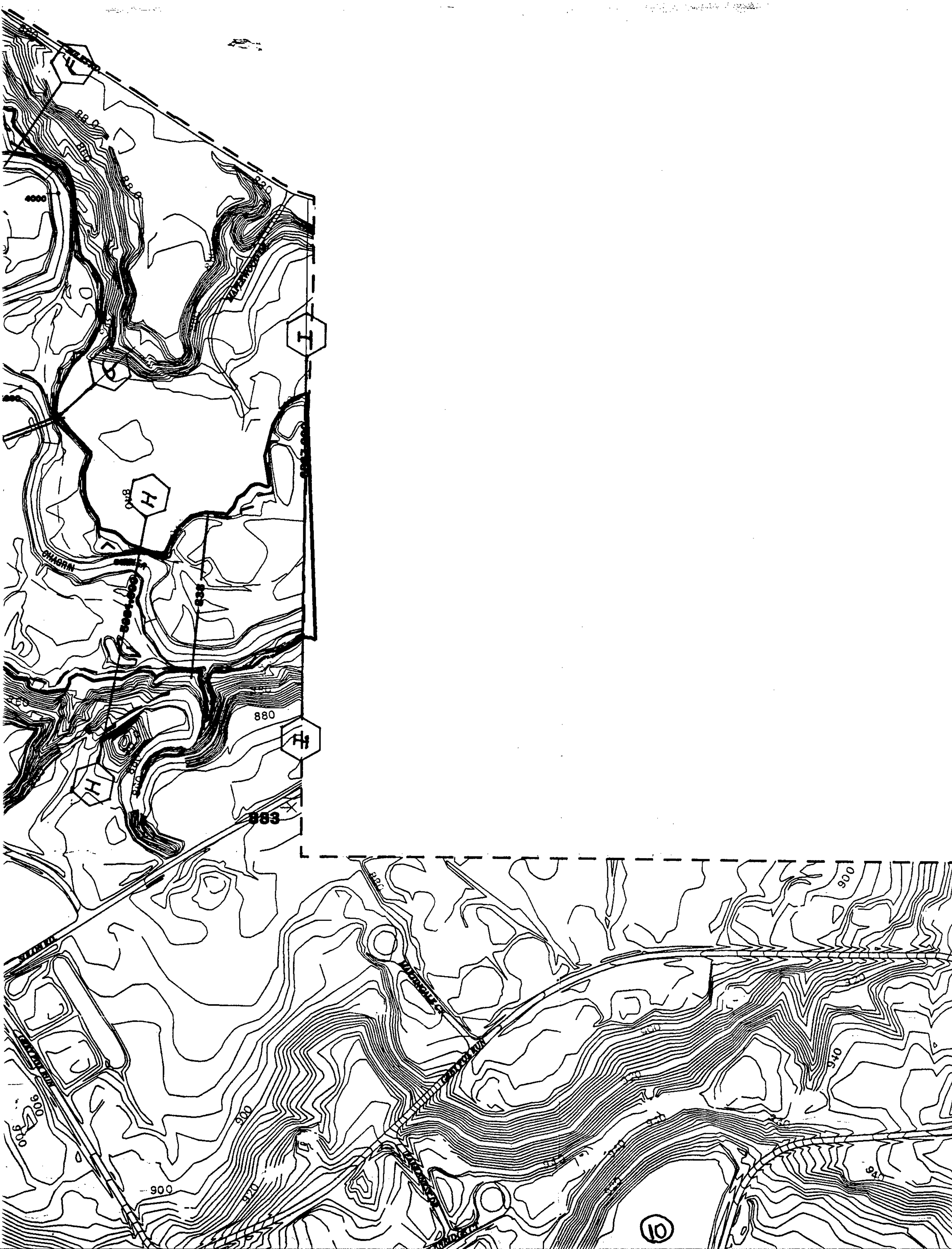

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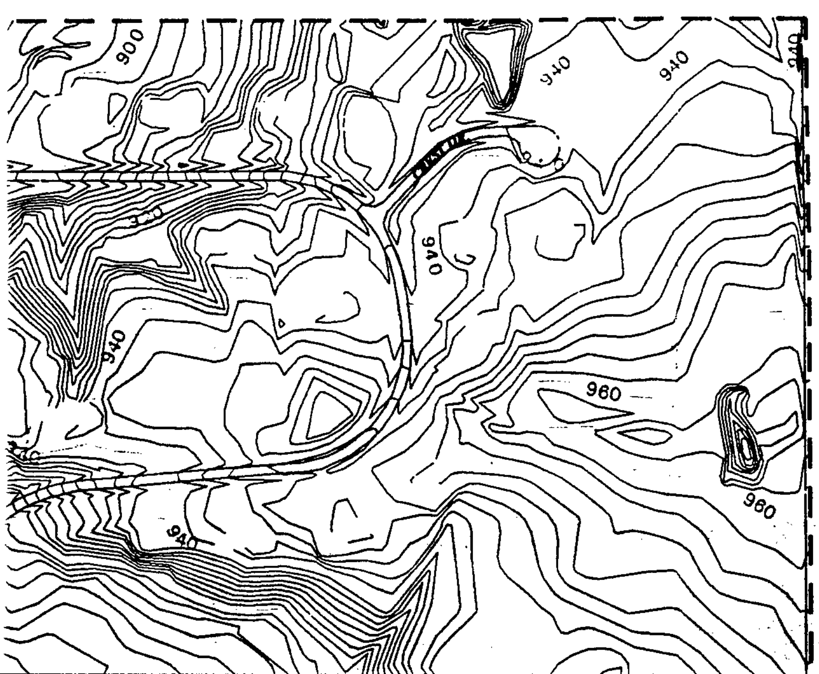

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KEY

Floodway

100yr Boundary

500yr Boundary

BFE

Study Limits

River Center

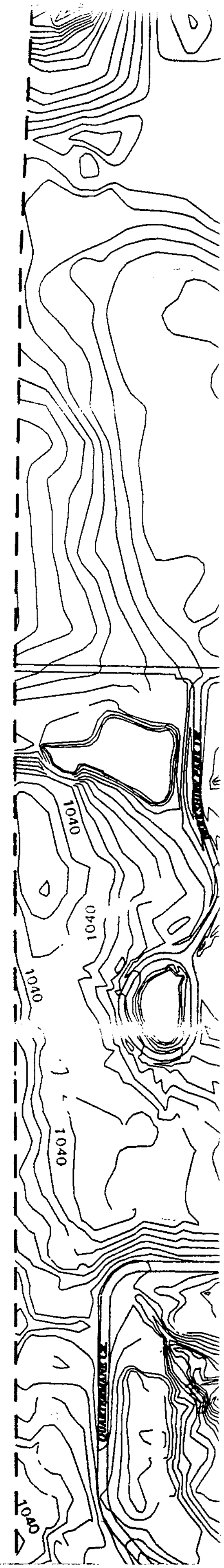
River Banks

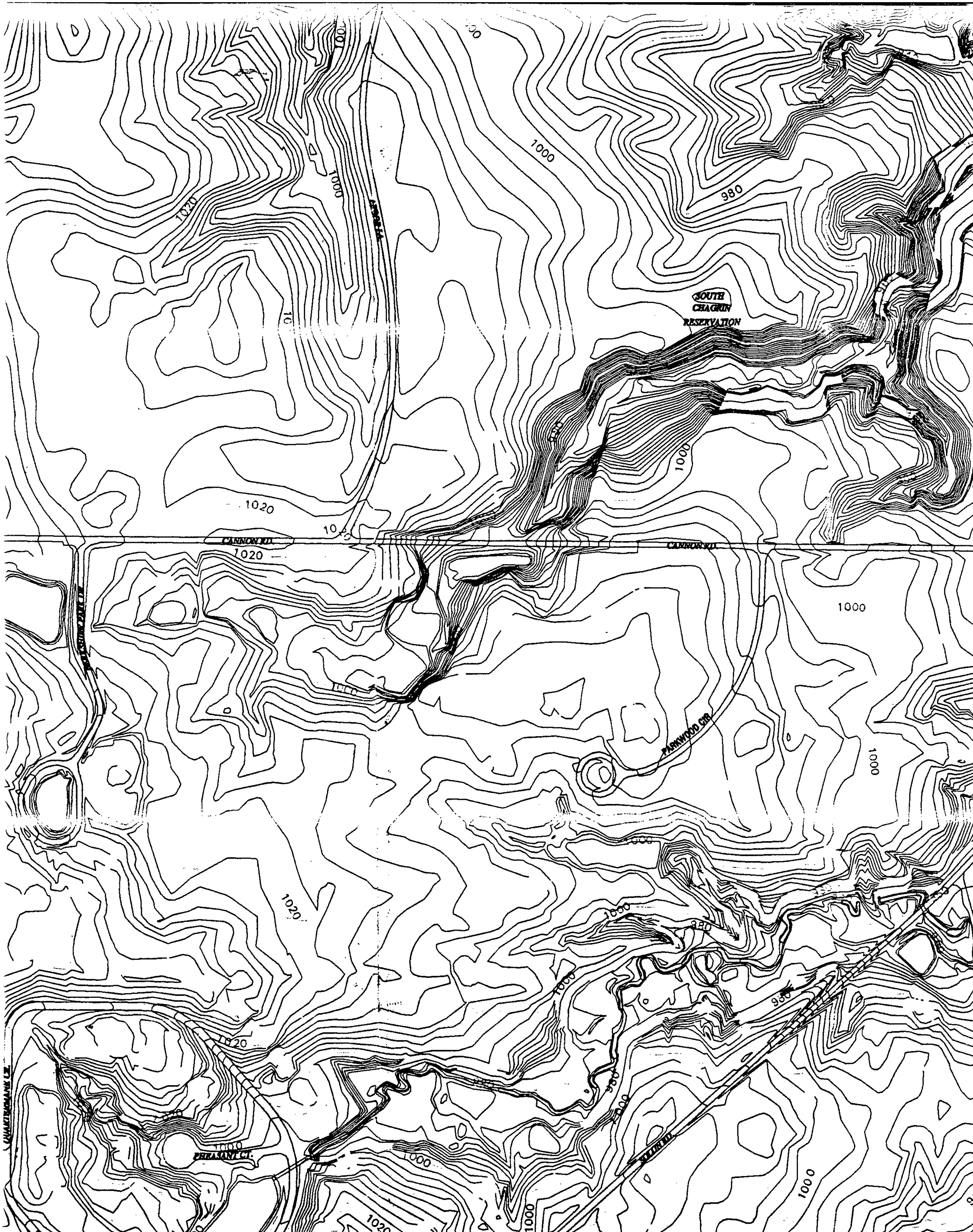
Cross Section

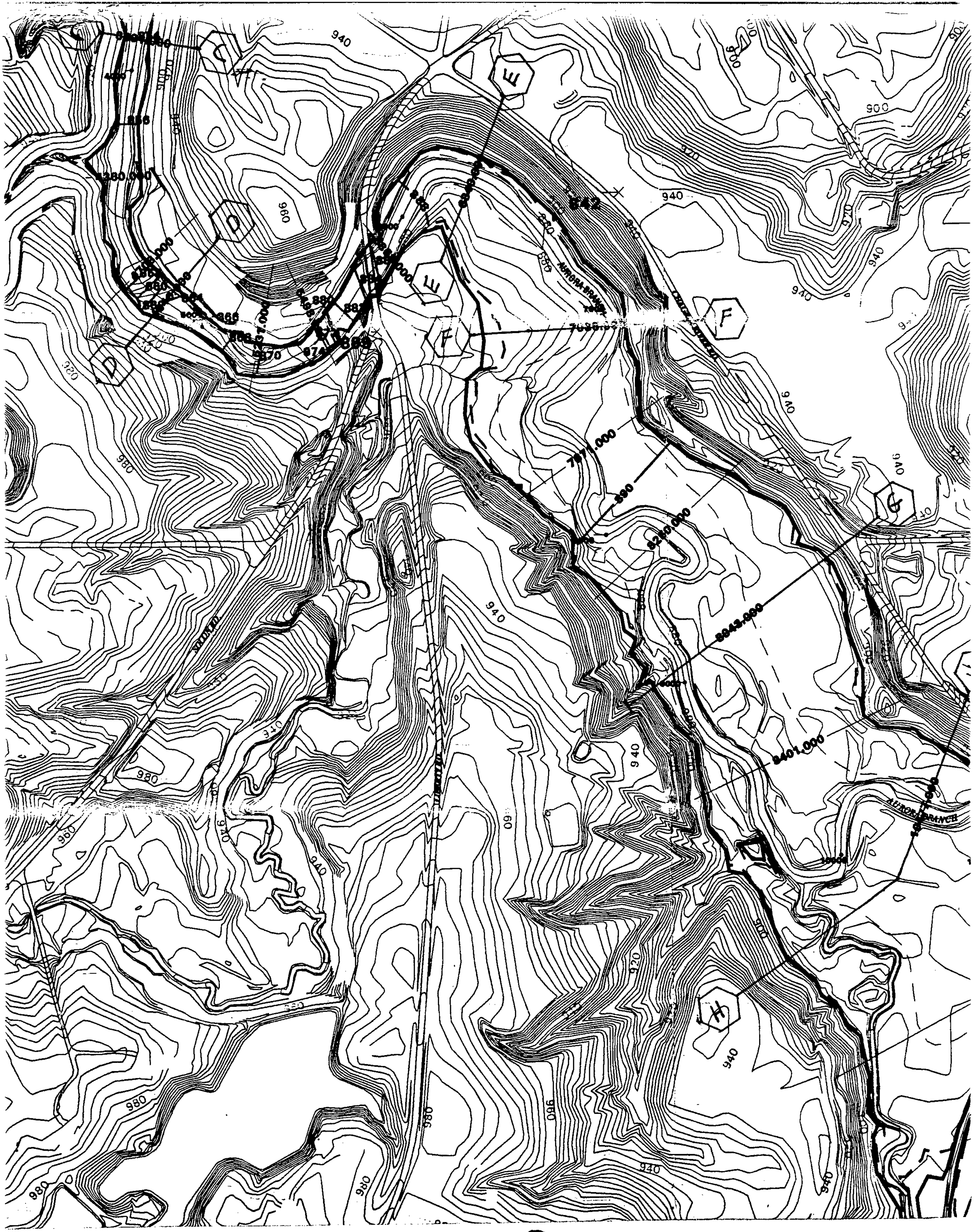
Streets

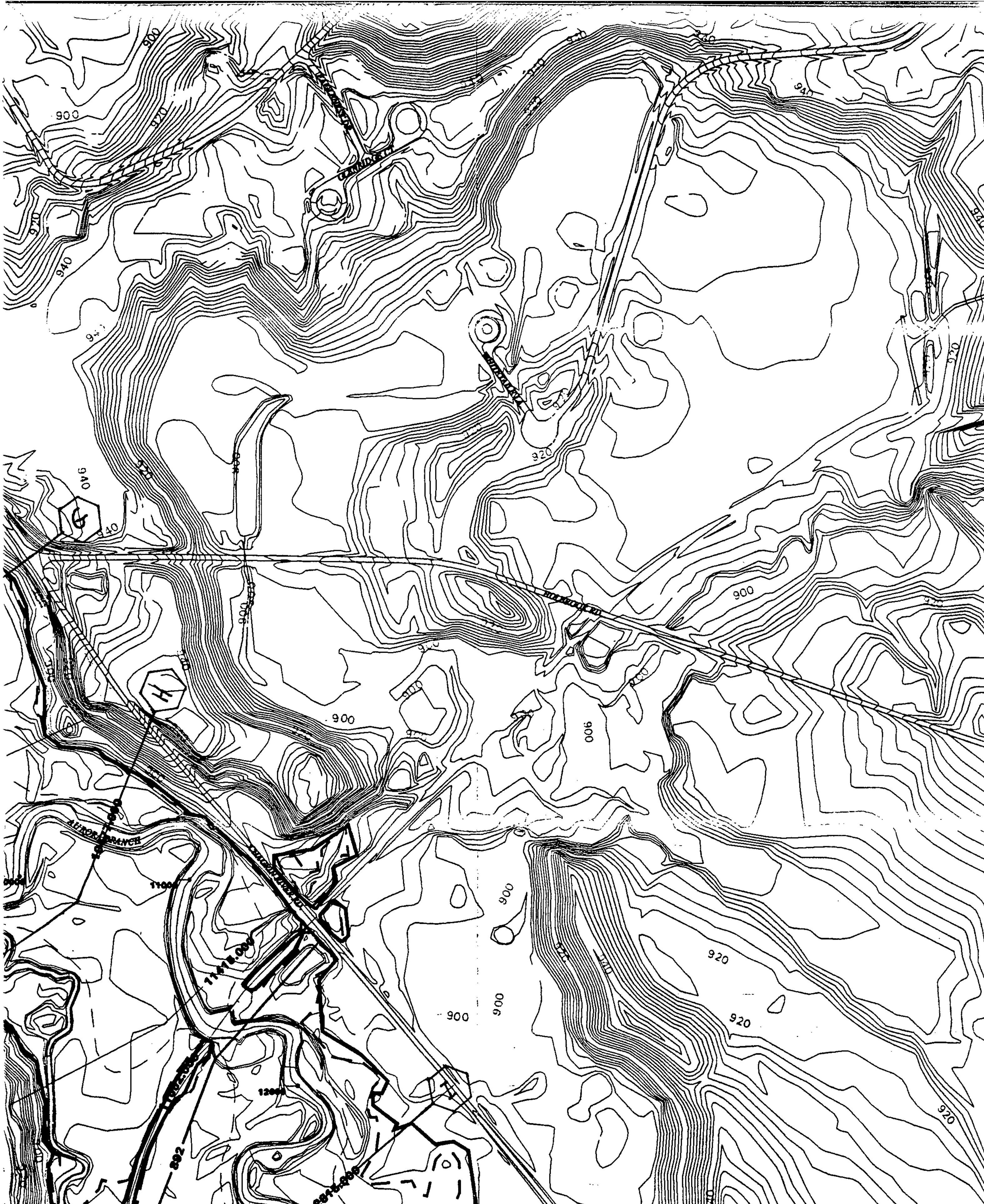
Railroads

Political


1040
1040
1040
1040
1040
1040


1000
1020
980
SOUTH CHAGRIN RESERVATION
CANNON RD.
PARKWOOD CIR
PHEASANT CT.
SOLON RD.


C
E
D
F
G
H
940
960
980
920
900
AURORA BRANCH
7571.000
8280.000
8843.000
9401.000


900
920
940
G
H
AURORA BRANCH
11000
12000


960
940
920

Railroads

Political Boundary

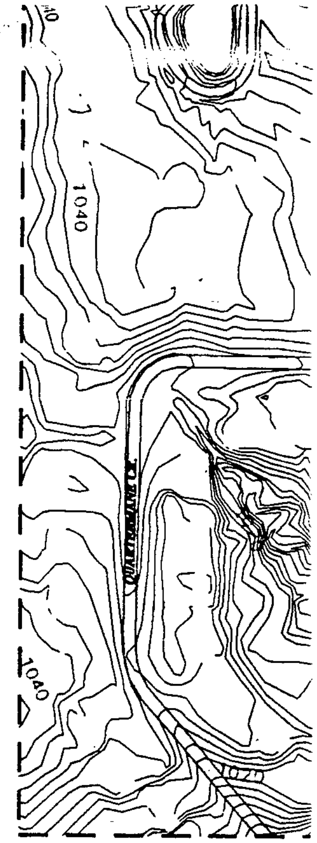
Model Limits

Area Not Included

2 ft Contours

20 ft Contours

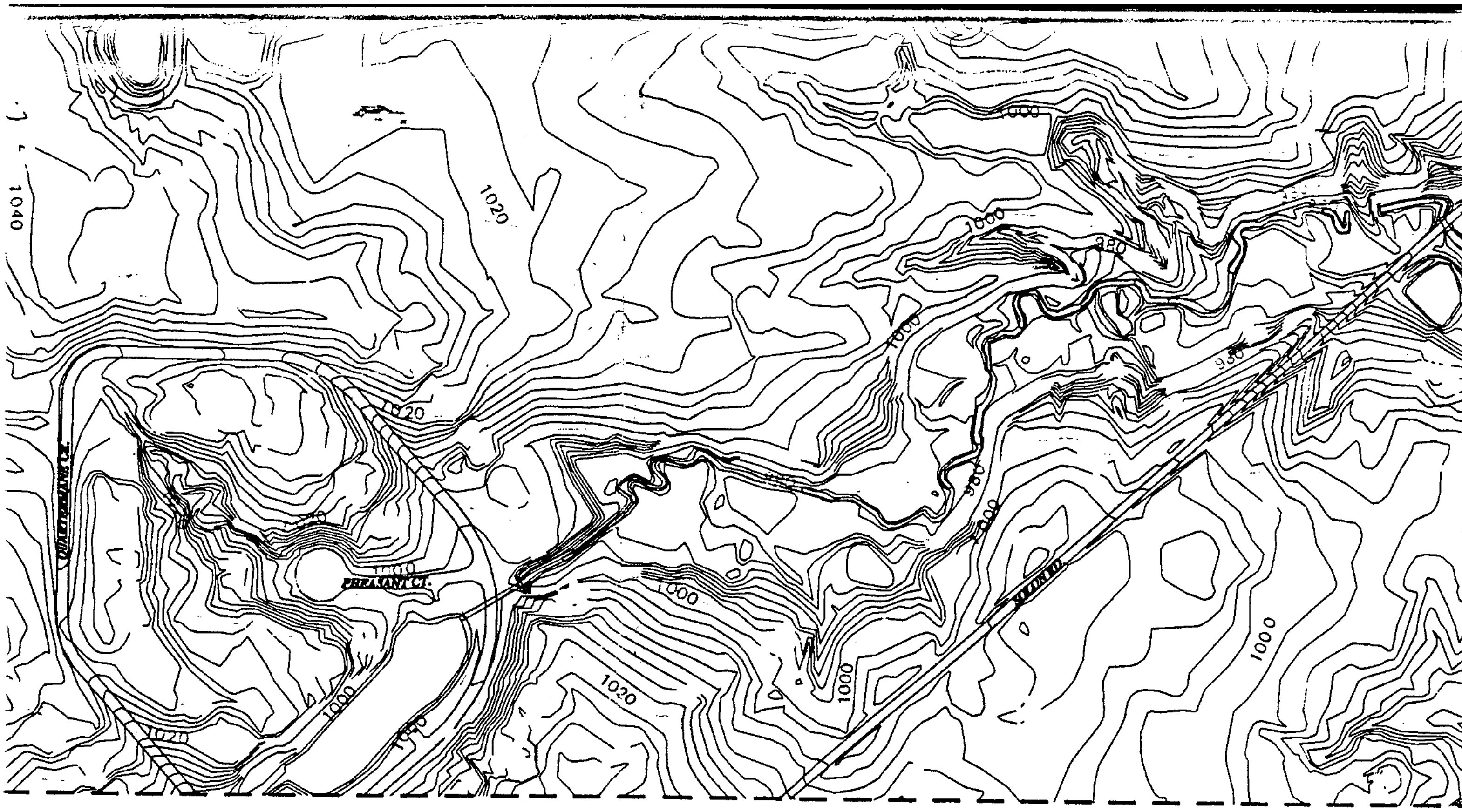
ERM



SPECIAL FLOOD HAZARD STUDY
BENTLEYVILLE, OHIO

CHAGRIN RIVER
AURORA BRANCH

19

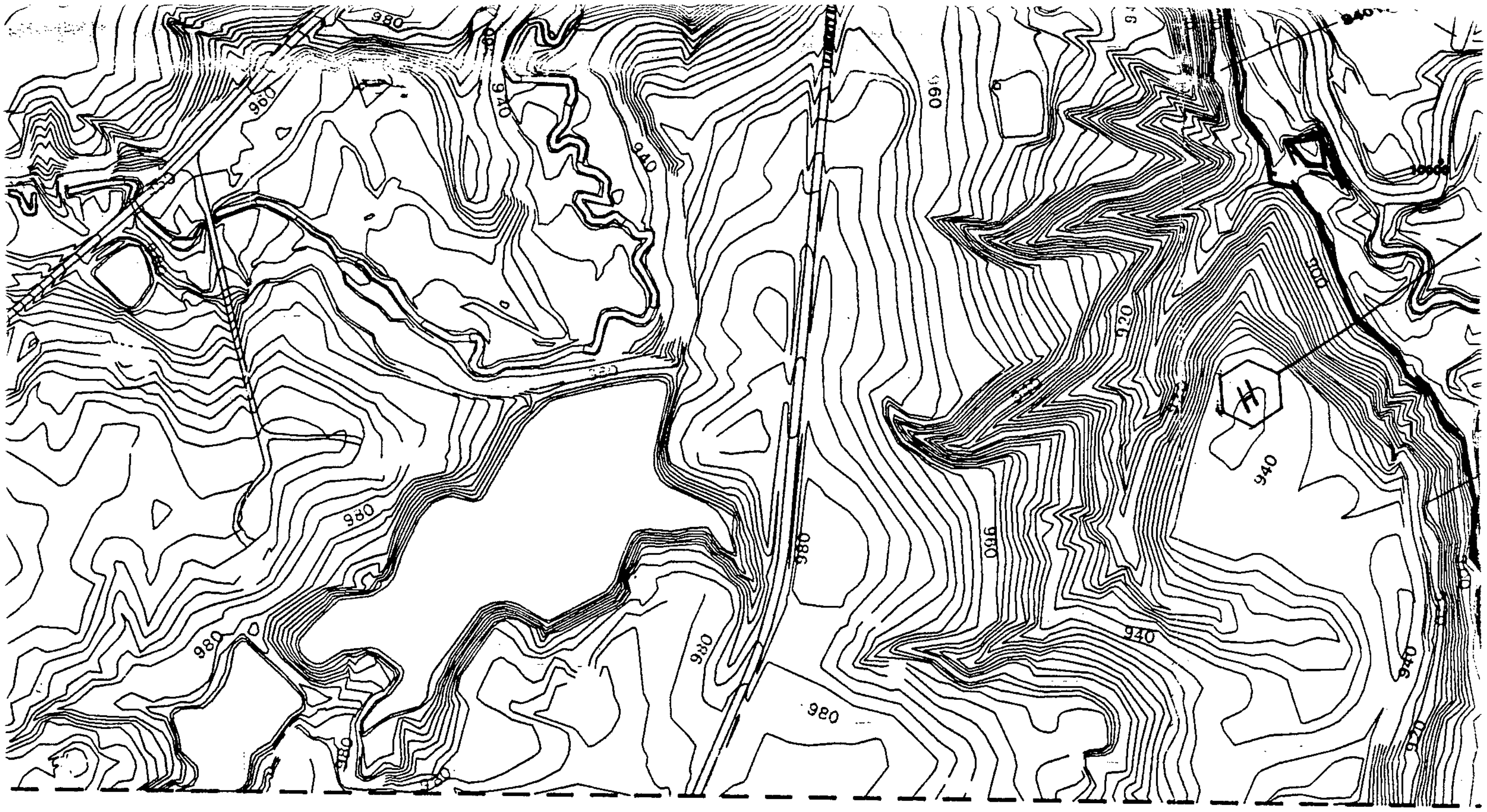


UDY

Base Mappi

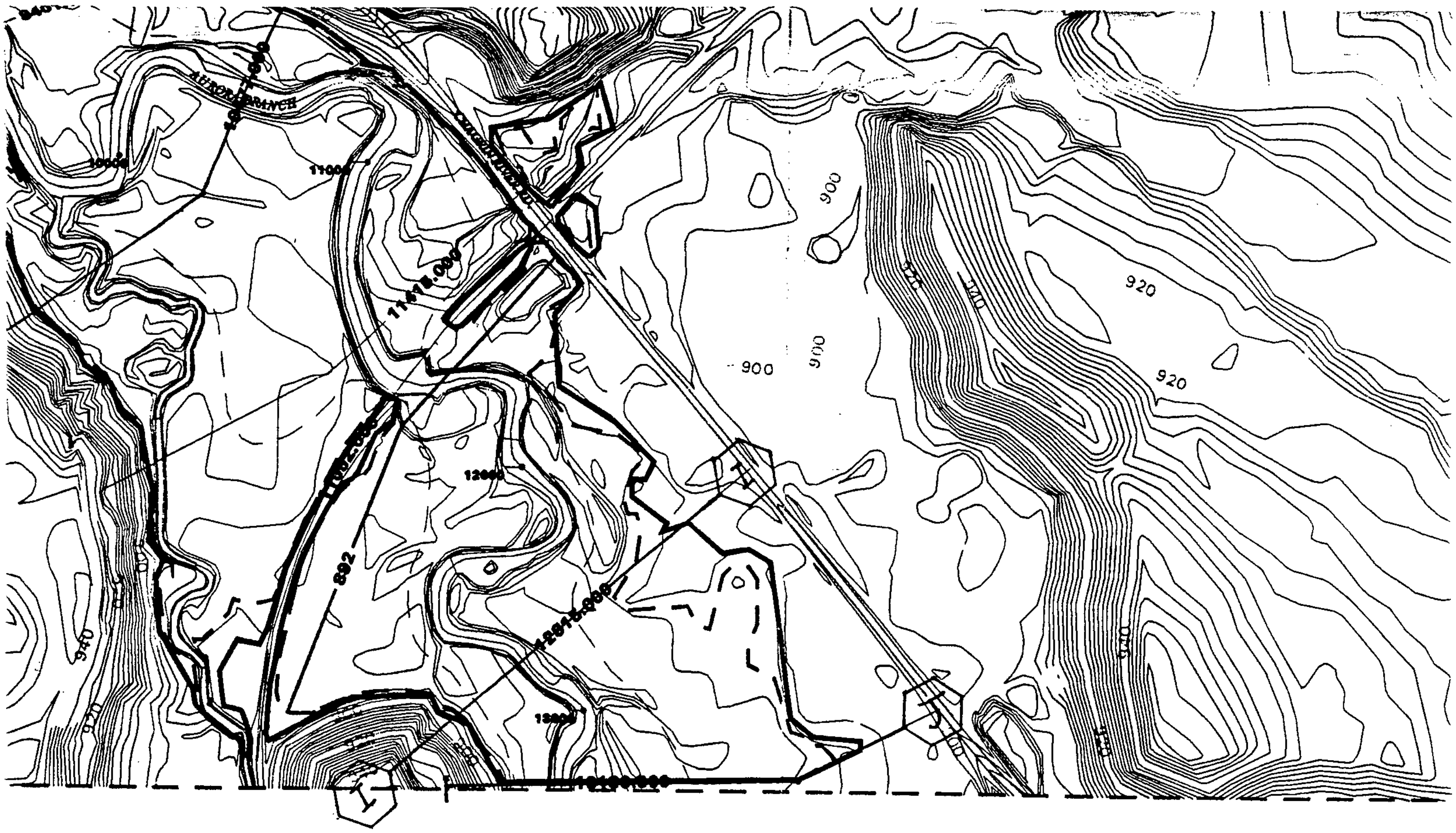
(20)

U



Mapping: CUYAHOGA COUNTY ENGINEER

21



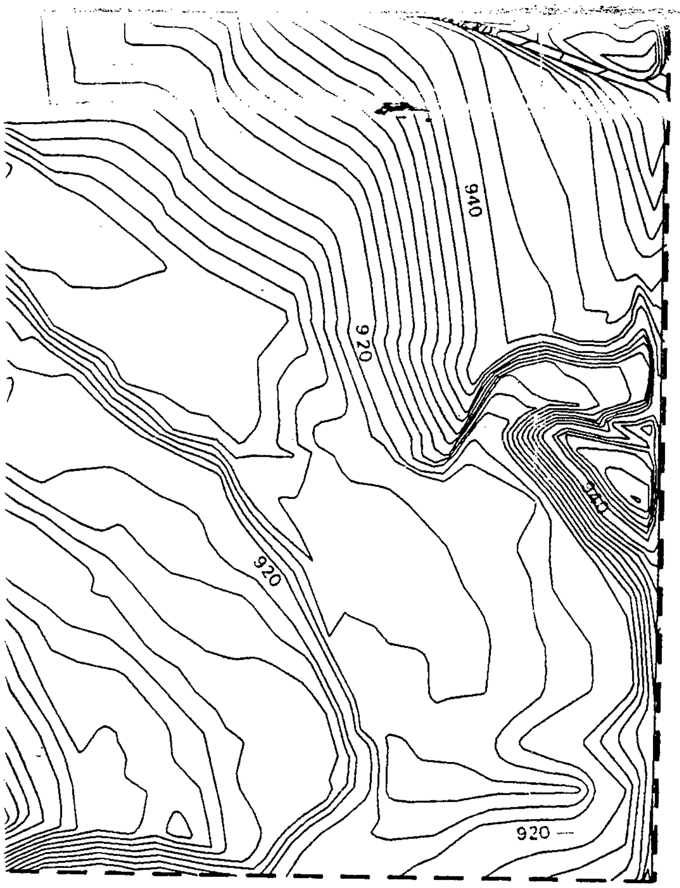
(22)

Scale 1” = 400’

S

Horz. Datum: NGVD27

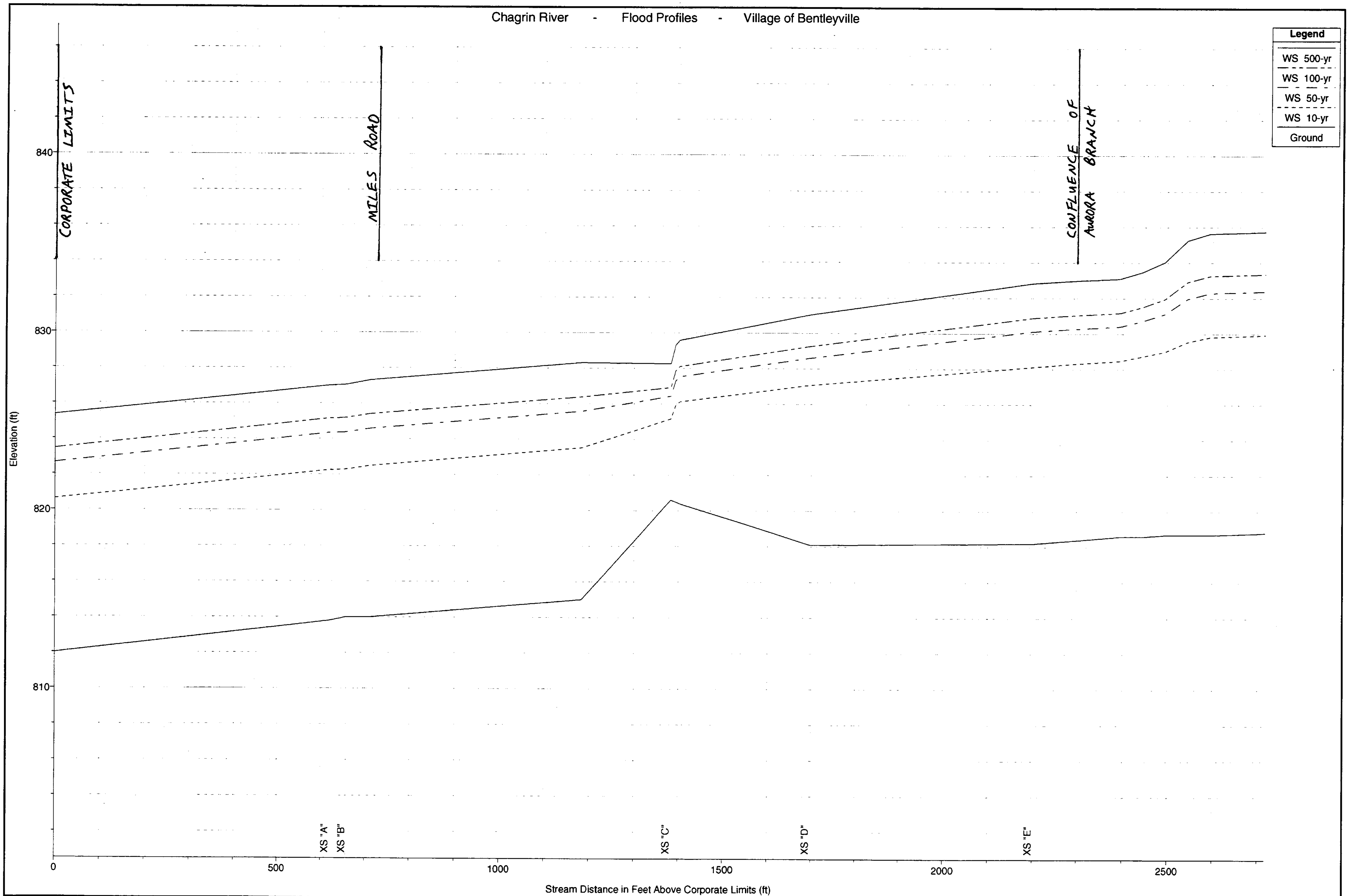
Vert. Datum: NGVD 1929



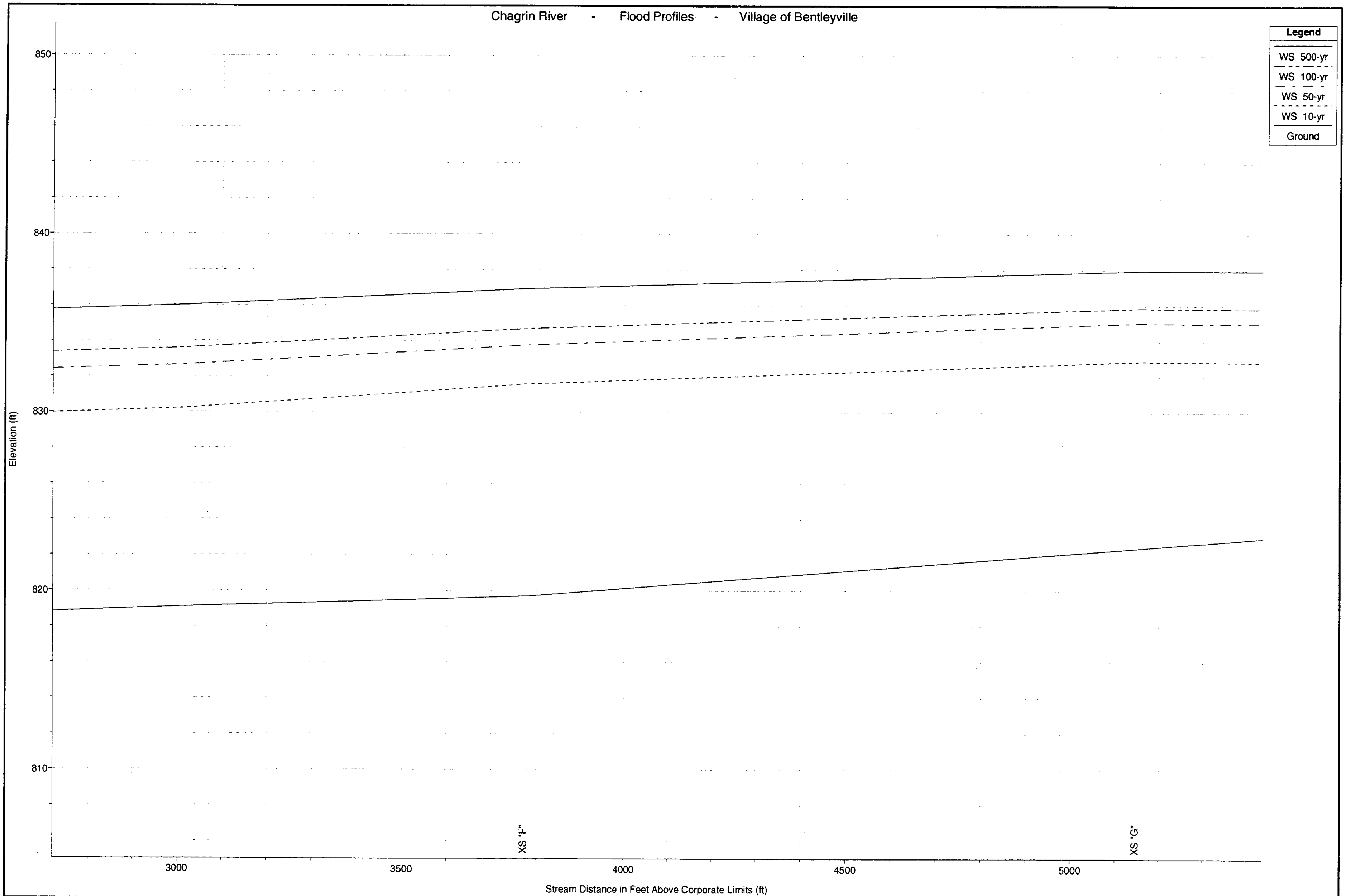
	Control Grid: CRGS
	(23) Date: March 21, 2000
'29	

ERM

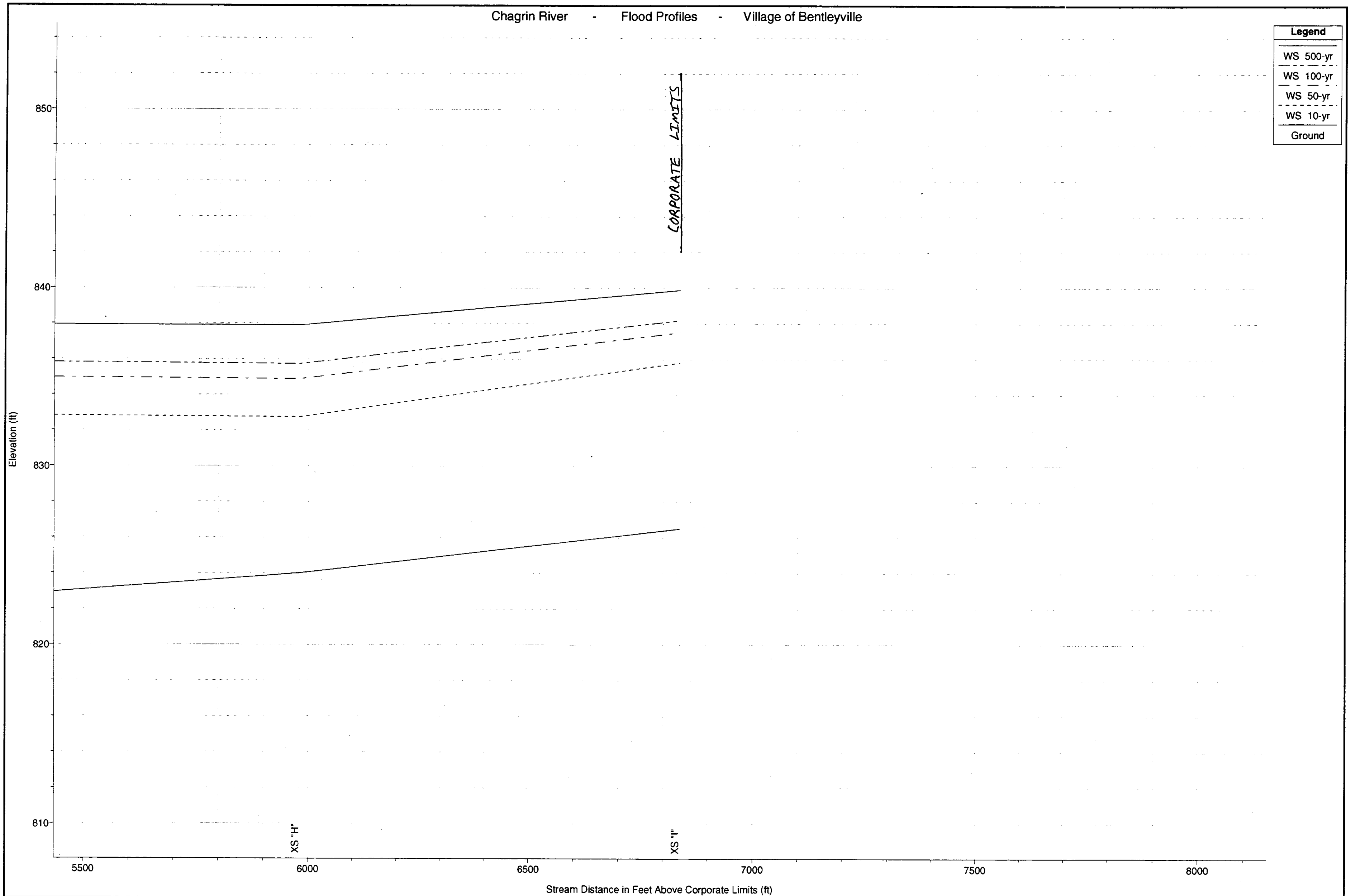
24



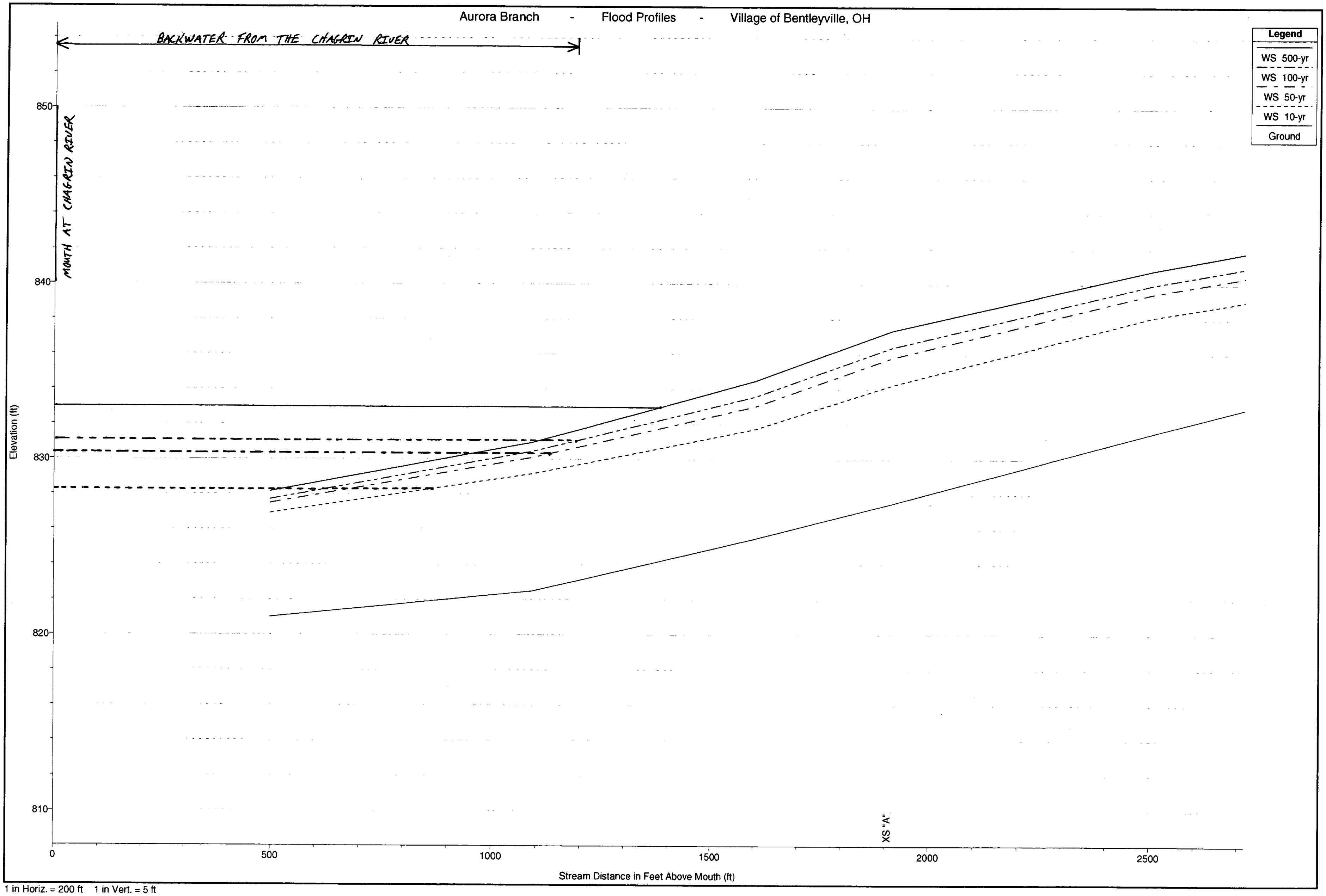
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft

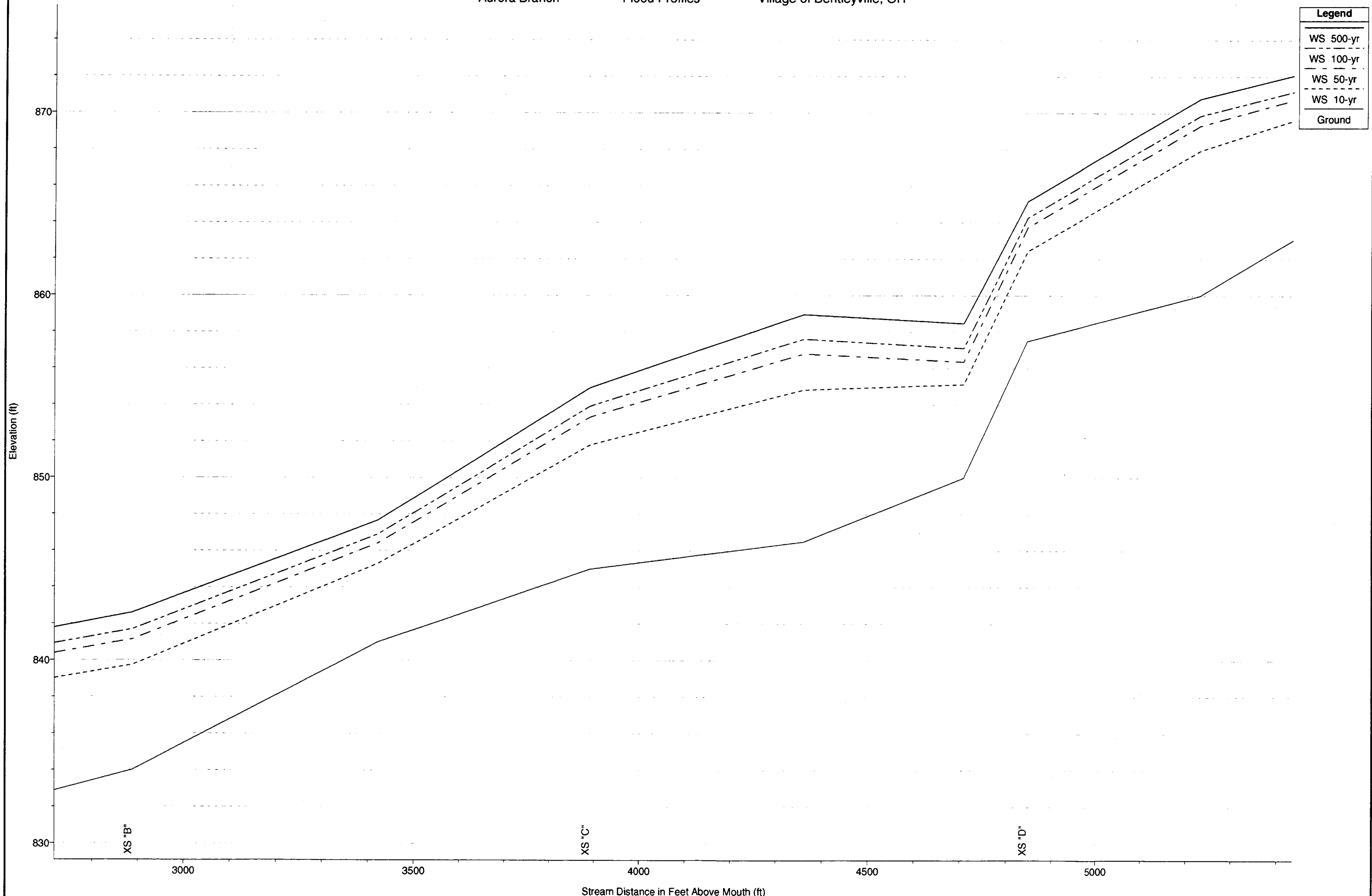


1 in Horiz. = 200 ft 1 in Vert. = 5 ft



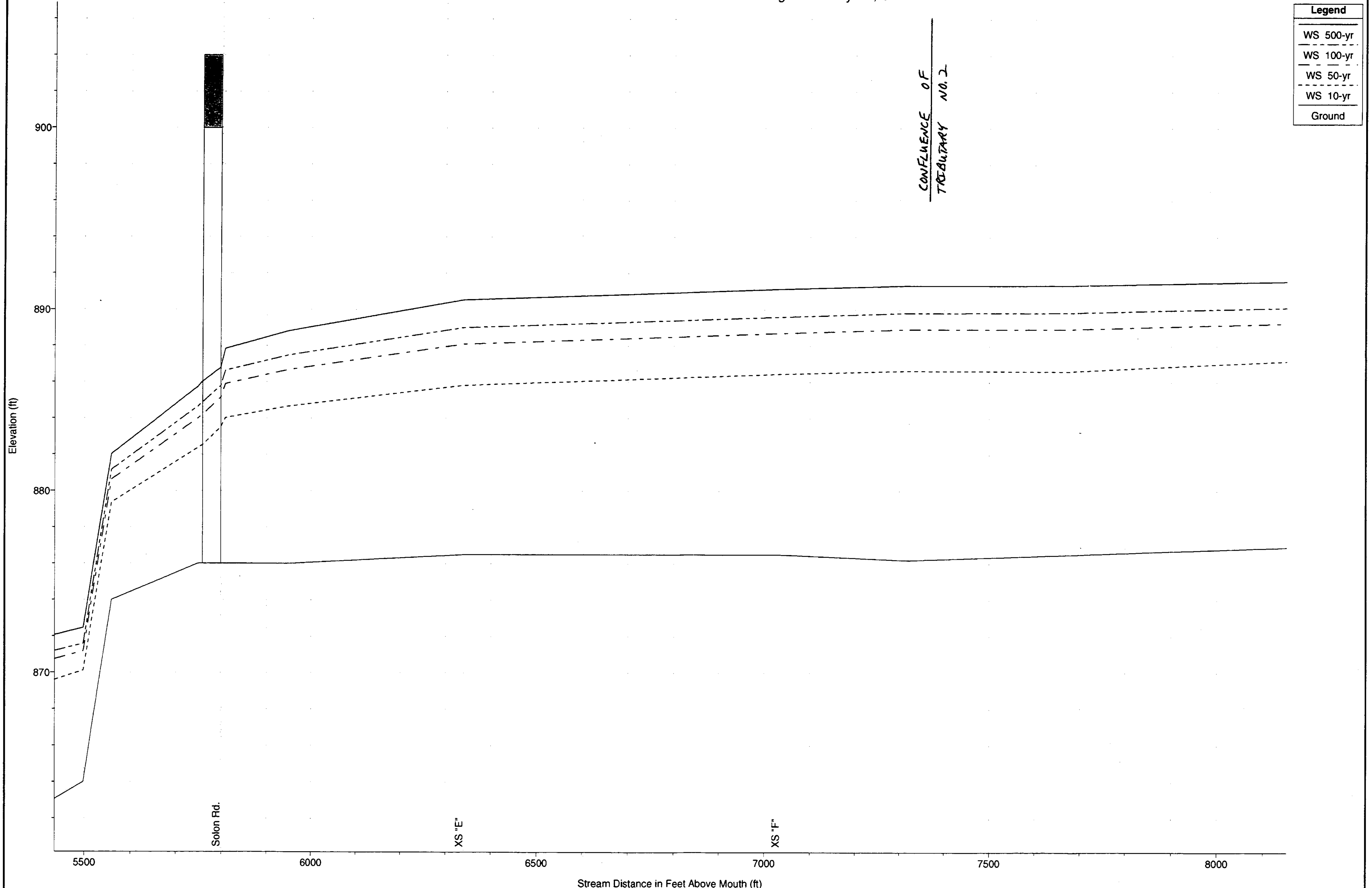
Aurora Branch - Flood Profiles - Village of Bentleyville, OH
BACKWATER FROM THE CHAGRIN RIVER
MOUTH AT CHAGRIN RIVER
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Elevation (ft)
850
840
830
820
810
0
500
1000
1500
2000
2500
XS "A"
Stream Distance in Feet Above Mouth (ft)
1 in Horiz. = 200 ft 1 in Vert. = 5 ft

Aurora Branch - Flood Profiles - Village of Bentleyville, OH



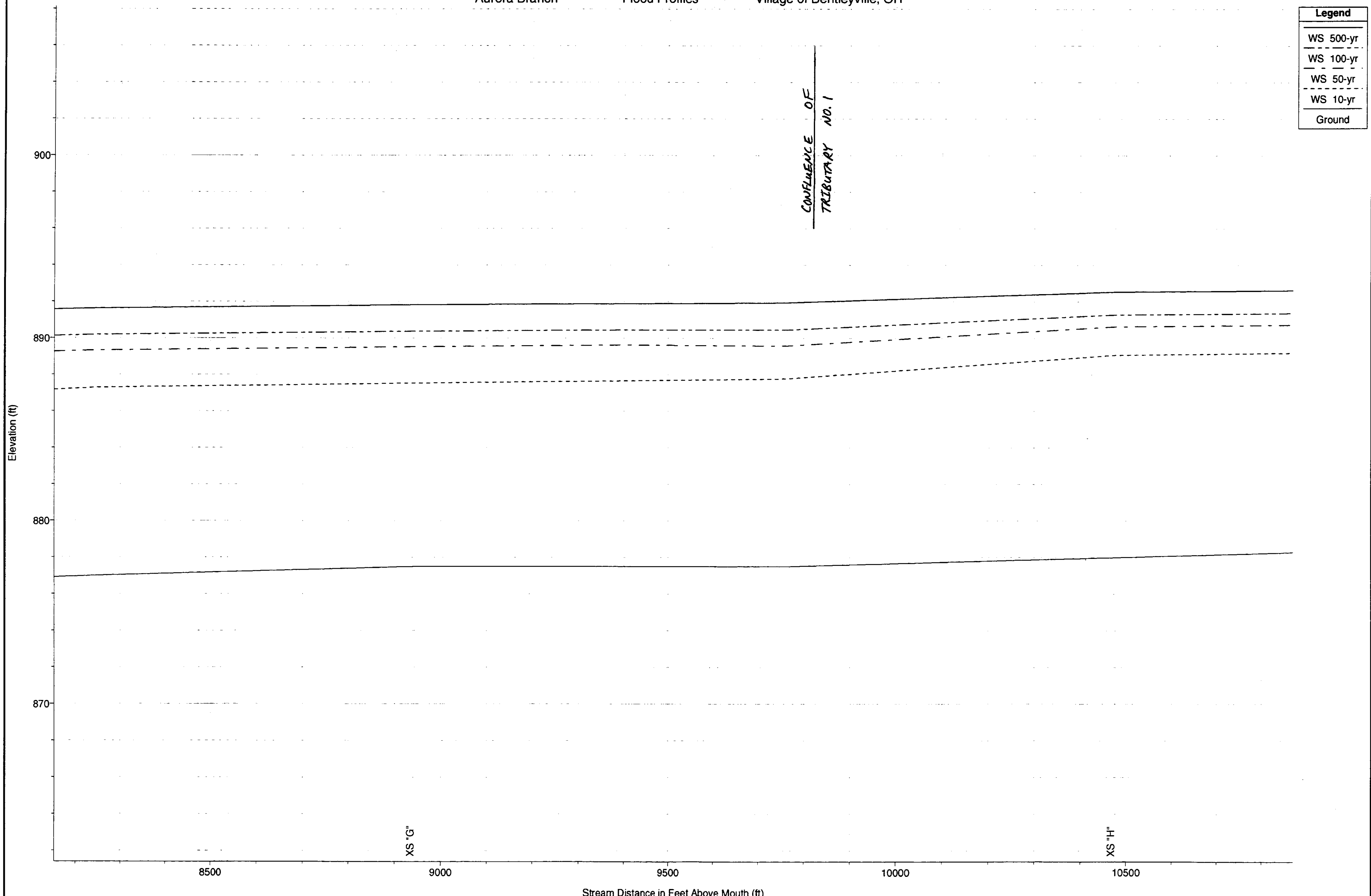
1 in Horiz. = 200 ft 1 in Vert. = 5 ft

Aurora Branch - Flood Profiles - Village of Bentleyville, OH



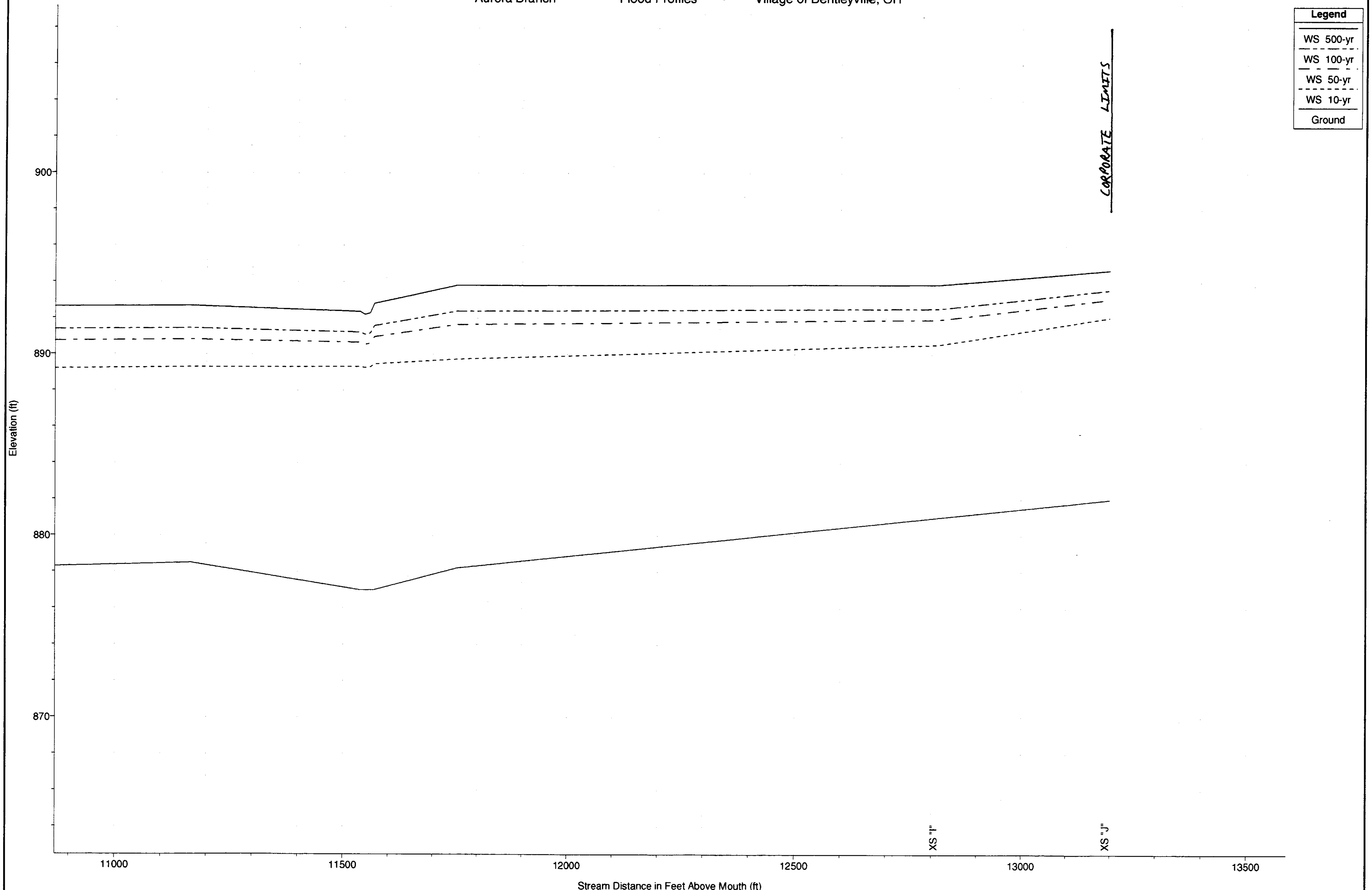
1 in Horiz. = 200 ft 1 in Vert. = 5 ft

Aurora Branch - Flood Profiles - Village of Bentleyville, OH



1 in Horiz. = 200 ft 1 in Vert. = 5 ft

Aurora Branch - Flood Profiles - Village of Bentleyville, OH



1 in Horiz. = 200 ft 1 in Vert. = 5 ft